

## TITLE OF THE INVENTION

## PRINTING APPARATUS AND PRINTING DATA CONTROL METHOD

## 5 FIELD OF THE INVENTION

The present invention relates to a printing apparatus and printing data control method and, more particularly, to a technique of processing printing data in a printing apparatus which performs printing by  
10 scanning a carriage that supports a printhead having a plurality of printing elements arrayed in a predetermined direction, on a printing medium in a direction perpendicular to the printing element array direction.

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## BACKGROUND OF THE INVENTION

A printer which performs printing information such as a desired character or image on a sheet-like printing medium such as a paper sheet or film is widely  
20 used as an information output apparatus in a wordprocessor, personal computer, facsimile apparatus, and the like.

Various methods are known as printing methods in the printer. Especially an ink-jet method has recently  
25 received a great deal of attention because this method can realize noncontact printing on a printing medium such as a paper sheet, easily prints in color, and is

quiet. Because of low cost and easy downsizing, a popular ink-jet arrangement is a serial printing system in which a printhead for discharging ink in accordance with desired printing information is mounted and prints  
5 while the printhead is reciprocally scanned in a direction perpendicular to the convey direction of a printing medium such as a paper sheet.

In order to widen a region printed by one scanning and increase the printing speed, the printhead  
10 of the ink-jet printer has many printing elements (nozzles) arrayed in almost the same direction as the printing medium convey direction. The ink-jet printer generally comprises a plurality of printing element arrays or printheads in correspondence with a plurality  
15 of inks for use for color printing and/or multitone printing.

In general, image data from a host device such as a personal computer is transmitted as raster data of one line that is rasterized in the scanning direction  
20 (horizontal direction). The printer which has received the raster data performs H-V conversion of rearranging image data in accordance with the printing element array direction (vertical direction).

In order to stably discharge ink at high speed  
25 from an ink-jet printer, the ink-jet printer adopts distributed discharge control of controlling to simultaneously discharge ink from a plurality of

nozzles arrayed at specific intervals, instead of simultaneously discharging ink from all nozzles.

When the ink-jet printer using distributed discharge control prints by color printing or the like  
5 using a plurality of inks, data management and distributed discharge driving control are executed for each ink used.

For example, in a color printer using three color inks of yellow, magenta, and cyan which are three  
10 primary colors in subtractive color mixing, the control circuit is constituted in accordance with the arrangement (the number of nozzles, the positional relationship of the printheads, and the like) of the printhead for each color. When printheads have  
15 different arrangements, the control circuit is changed in accordance with each arrangement.

In recent years, ink-jet printers are increasingly used for various purposes, and demands have arisen for higher printing speed and higher image  
20 quality. In this situation, the printhead arrangement varies in accordance with the application and purpose.

To facilitate the development and realize low cost, it is desirable to design a control circuit capable of coping with various printhead arrangements.

25 More specifically, the control circuit is so designed as to arrange a buffer memory for each printhead and generate data to be transferred to the

head. Due to various printhead arrangements, the control circuit takes a different circuit arrangement for the arrangement of each printhead for use, and cannot be utilized in a printhead having another  
5 arrangement.

For example, in the simplest arrangement in which a buffer memory for storing data to be printed by one scanning is arranged for each printhead (ink), the capacity of the buffer memory changes in accordance  
10 with the printing medium size and resolution used for printing. When the buffer memory is formed in a very large scale integrated circuit (VLSI) for higher processing speed, the buffer memory occupies most of the region on the VLSI. If the buffer memory is  
15 downsized, but a plurality of types of buffer memories are formed in correspondence with printheads with a plurality of arrangements, the physical region occupied by the memories inefficiently increases.

Some control circuits are so configured as to  
20 simultaneously access data at a plurality of addresses in order to efficiently access the memory in accordance with the printhead specifications. Such circuit comprises, e.g., a register and counter for setting the start address, as shown in Fig. 11. By using the  
25 counter, data in number set at the counter can be accessed from a desired address.

However, this circuit arrangement limits the

specifications of a compatible printhead. Depending on the contents of a specification change, the control circuit must be changed.

As described above, it is difficult for  
5 printheads with various arrangements to commonly employ a control circuit for the printhead and a large-scale logical circuit including the control circuit. The control circuit of the printhead inhibits efficient development and low-cost apparatuses.

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#### SUMMARY OF THE INVENTION

It is an object of the present invention to allow printheads with various arrangements to use a common control circuit in a serial printing type printing  
15 apparatus.

To achieve the above object, according to one aspect of the present invention there is provided a printing apparatus which performs printing by scanning a carriage that supports a printhead having a plurality  
20 of printing elements arrayed in a predetermined direction, on a printing medium in a direction perpendicular to the predetermined direction, comprising: a printing data memory which stores printing data of a raster format; a buffer memory which  
25 has a storage area corresponding to each printing element and stores printing data stored in the printing data memory; a head parameter unit which stores

information on an arrangement of the printhead; and a buffer controller which controls, in accordance with the information stored in the head parameter unit, processing of reading out the printing data stored in the printing data memory and storing the printing data in the buffer memory, and processing of reading out the printing data stored in the buffer memory.

According to the present invention, in a printing apparatus which performs printing by scanning a carriage that supports a printhead having a plurality of printing elements arrayed in a predetermined direction, on a printing medium in a direction perpendicular to the predetermined direction, printing data of a raster format obtained by processing transmitted image information into data used for printing, or printing data transmitted in the raster format is stored in a printing data memory. The printing data stored in the printing data memory is stored in a buffer memory having a storage area corresponding to each printing element. This arrangement adopts a head parameter unit which stores information on the printhead arrangement. Processing of reading out the printing data stored in the printing data memory and storing the printing data in the buffer memory, and processing of reading out the printing data stored in the buffer memory are controlled in accordance with the information stored in the head

parameter unit.

This arrangement enables using a common control circuit for printheads having various arrangements. The use of a common control circuit can reduce the cost  
5 and shorten the apparatus design period.

The information stored in the head parameter unit may include at least the number of nozzle arrays of the printhead, the number of nozzles which constitute the nozzle arrays, and nozzles to be driven in the nozzle  
10 arrays.

The buffer controller may convert the raster data into column data in reading out the printing data stored in the buffer memory.

The buffer controller may read out the printing  
15 data stored in the buffer memory from each address.

In this case, the printhead may perform distributed driving for a predetermined number of nozzles, and the buffer controller calculates a read address in accordance with a distributed driving number  
20 in reading out the printing data stored in the buffer memory.

Further, the buffer controller may include a register which holds, by a plurality of addresses, data of predetermined bits read out by accessing each  
25 address of the buffer memory.

According another aspect of the present invention, there is provided a printing apparatus which

performs printing by scanning a printhead having a plurality of printing elements arrayed in a predetermined direction, on a printing medium in a direction perpendicular to the predetermined direction, comprising: a printing data memory which stores printing data of a raster format; a plurality of buffer memories which store raster data of predetermined bits in correspondence with the respective printing elements; a head parameter unit which holds information on the printhead; acquisition means for acquiring address information subjected to read in the printing data memory on the basis of the information on the printhead in storing the printing data read out from the printing data memory in the buffer memory; a buffer controller which stores the printing data read out from the printing data memory in the buffer memory, on the basis of the address information of the printing data memory that is acquired by the acquisition means; and transfer means for transferring the data read out from the buffer memory to the printhead.

In addition to the above aspects of the printing apparatus, the present invention can also be realized by the aspect of a printing data control method in the printing apparatus, the aspect of a computer program which realizes the printing data control method, and the aspect of a storage medium which stores the computer program.



Other features and advantages of the present invention will be apparent from the following description taken in conjunction with the accompanying drawings, in which like reference characters designate  
5 the same or similar parts throughout the figures thereof.

#### BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated  
10 in and constitute a part of the specification, illustrate embodiments of the invention and, together with the description, serve to explain the principles of the invention.

Fig. 1 is a view showing an arrangement example  
15 of a buffer memory according to an embodiment of the present invention;

Fig. 2 is a block diagram showing a control arrangement according to the embodiment of the present invention;

20 Fig. 3 is a view for explaining an arrangement example of a printhead;

Fig. 4 is a view for explaining another arrangement example of the printhead;

Fig. 5 is a flow chart showing buffer processing  
25 for printing data according to the embodiment;

Figs. 6A to 6I are timing charts showing changes in signals according to the embodiment;

Fig. 7 is a perspective view showing the schematic outer appearance of an ink-jet printer as a preferable embodiment of the present invention;

Figs. 8A to 8K are views showing a description  
5 example in a hardware description language;

Fig. 9 is a table showing an example of information stored in a head parameter unit;

Fig. 10 is an explanatory view showing read processing from a buffer memory;

10 Fig. 11 is a block diagram showing access control to a conventional print buffer;

Fig. 12 is a block diagram showing the arrangement of a buffer controller according to the embodiment of the present invention;

15 Fig. 13 is a view showing the principle of read from a printing data memory when nozzle arrays are serially arranged according to the embodiment of the present invention; and

Fig. 14 is a view showing the principle of read  
20 from the printing data memory when nozzle arrays are parallel-arranged according to the embodiment of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

25 Preferred embodiments of the present invention will now be described in detail in accordance with the accompanying drawings.

In the following embodiments, a printing apparatus utilizing an inkjet printing system is explained as an example.

In this specification, "print" is not only to  
5 form significant information such as characters and graphics, but also to form, e.g., images, figures, and patterns on printing media in a broad sense, regardless of whether the information formed is significant or insignificant or whether the information formed is  
10 visualized so that a human can visually perceive it, or to process printing media.

"Print media" are any media capable of receiving ink, such as cloth, plastic films, metal plates, glass, ceramics, wood, and leather, as well as paper sheets  
15 used in common printing apparatuses.

Furthermore, "ink" (to be also referred to as a "liquid" hereinafter) should be broadly interpreted like the definition of "print" described above. That is, ink is a liquid which is applied onto a printing  
20 medium and thereby can be used to form images, figures, and patterns, to process the printing medium, or to process ink (e.g., to solidify or insolubilize a colorant in ink applied to a printing medium).

Fig. 7 is a perspective view showing the  
25 schematic outer appearance of an ink-jet printer IJRA as a typical embodiment of the present invention. In Fig. 7, a pin (not shown) is attached to a carriage HC

which engages with a helical groove 5004 of a lead screw 5005 that rotates via driving force transfer gears 5009 to 5011 while interlocking with forward/reverse rotation of a driving motor 5013. The carriage HC is supported by a guide rail 5003 and reciprocates in directions indicated by arrows a and b. The carriage HC supports an integral ink-jet cartridge IJC which incorporates a printhead 10 and ink tank IT.

Reference numeral 5002 denotes a sheet press plate which presses a printing sheet P against a platen 5000 in the moving direction of the carriage HC. Reference numerals 5007 and 5008 denote photocouplers serving as home position detectors for detecting the presence of a carriage lever 5006 in a corresponding region and switching the rotational direction of the motor 5013.

Reference numeral 5016 denotes a member which supports a cap member 5022 that caps the front surface of the printhead 10; and 5015, a suction unit which sucks the interior of the cap and performs suction recovery of the printhead via an intra-cap opening 5023. Reference numeral 5017 denotes a cleaning blade; and 5019, a member capable of moving this blade back and forth. The cleaning blade 5017 and member 5019 are supported by a main body support plate 5018. The blade is not limited to this embodiment, and a known cleaning blade can be applied to the embodiment.

Reference numeral 5021 denotes a lever which starts suction recovery operation, and moves together with movement of a cam 5020 engaged with the carriage. A driving force from the driving motor is controlled by  
5 a known transfer mechanism such as a clutch switch.

Capping, cleaning, and suction recovery are executed by desired processes at corresponding positions by the operation of the lead screw 5005 when the carriage comes to the home-position region. This  
10 embodiment can adopt any setting as long as desired operations are done at known timings.

Fig. 2 is a block diagram showing a control arrangement for printing by the ink-jet printer according to the embodiment.

15 As shown in Fig. 2, the control block for printing by the printer according to the embodiment includes a printing controller 1 which controls printing, a CPU 5 which controls the whole apparatus, a printing data memory 6 which stores printing data, a  
20 memory controller 12 which controls access to the printing data memory 6, the printhead 10 which maintains and recovers the discharge performance for ink and prints, and a printing mechanism driving unit 9 including a carriage driving mechanism supporting the  
25 printhead and a printing medium convey mechanism.

The printing controller 1 includes a buffer memory 7, a buffer controller 2 which controls access

to the buffer memory, a printing data converter 3  
complying with the transfer method (interface) to the  
printhead, a head parameter unit 4 which stores  
information on the printhead arrangement, and a  
5 printing timing controller 8 which controls the timing  
signal on the basis of information from the printing  
mechanism driving unit.

As shown in Fig. 12, the buffer controller 2  
comprises a buffer designation register 121 which  
10 refers to the states of buffers 7-1 and 7-2 in  
storage/read in/from the buffer memory 7.

The buffer controller 2 also comprises a column  
counter 122, data pack register 123, and column  
division counter 124 which are used for read from the  
15 buffer memory 7. The data pack register holds at once  
a plurality of bits of 1-bit data read out from the  
buffer memory 7. The buffer controller 2 further  
comprises a color counter 125 and nozzle counter 126  
which are used for storage in the buffer memory 7.

20 The buffer controller 2 can parallel-execute  
storage processing and read processing for the buffer  
memory 7. For example, storage processing in the  
buffer memory 7-1 and read processing from the buffer  
memory 7-2 can be simultaneously executed.

25 As the outline of printing processing in the  
embodiment, the CPU 5 reads out a printing control  
program from the memory which stores a CPU control

program (not shown). An operation signal is supplied from an electrical circuit (not shown) to the printing mechanism driving unit 9, and positional information or the like is received from the printing mechanism driving unit 9 which operates in accordance with the signal. Raster data stored in the printing data memory 6 is stored in the buffer memory 7 within the printing controller 1. In read from the buffer memory 7, the raster data is converted into a column format. The data is then transferred to the printhead 10 to print.

The transfer method to the printhead 10 is serial transfer in this case, but may be parallel transfer. In serial transfer, data are transferred via one data line. The serially transferred data are converted into parallel data by a logic circuit which is incorporated in the printhead and includes a shift register and latch. The parallel data are supplied to the driving circuits of printing elements. In parallel transfer, data are transferred via, e.g., 16 data lines.

Figs. 3 and 4 are views showing the typical nozzle arrangement of the printhead mounted in the printer according to the embodiment. Figs. 3 and 4 exemplify the use of three types of inks. However, the number of ink types for use may be three or more.

Fig. 3 illustrates an arrangement in which three printheads 301 to 303 each having a plurality of nozzles (0 to n) for each ink are aligned. The

printhead prints by moving (scanning) it in a direction perpendicular to the direction in which the nozzles of the three printheads are aligned. After the end of each scanning, the printing medium is repetitively  
5 conveyed in almost the same direction as the nozzle array direction, thereby printing on one printing medium.

In the use of the three types of inks, like this example, the printing medium is conveyed by a distance  
10 corresponding to the length of one printhead (length of the nozzle array) after the end of each scanning. The three types of inks can be selectively discharged to the same position (pixel) to print by the three types of inks.

15 More specifically, assume that the printhead 301 discharges cyan ink, the printhead 302 discharges magenta ink, and the printhead 303 discharges yellow ink. A pixel printed by a nozzle C0-0 in the first scanning undergoes printing by a nozzle C1-0 in the  
20 second scanning and a nozzle C2-0 in the third scanning. This can realize color mixing printing using inks of three colors.

Fig. 4 also illustrates an arrangement in which three nozzle arrays 401 to 403 each having a plurality  
25 of nozzles (0 to n) for each ink are parallel-arranged. Also in this case, the scanning direction and printing medium convey direction are the same as those in Fig. 3.



After the end of each scanning, the printing medium is repetitively conveyed in almost the same direction as the nozzle array direction by a distance corresponding to the length of one nozzle array, thereby printing on  
5 one printing medium.

From the comparison between the arrangements in Figs. 3 and 4, they are different in that the three nozzle arrays are so serially arranged in a line in the arrangement of Fig. 3, but are parallel-arranged at the  
10 same horizontal position in the arrangement of Fig. 4.

In the arrangement shown in Fig. 4, three types of inks can be selectively discharged to the same pixel by one scanning. That is, color printing can be achieved by one pass, but the arrangement of Fig. 4  
15 requires control of driving the three nozzle arrays at different timings.

As the printhead arrangement, various arrangements are known in addition to those shown in Figs. 3 and 4. The arrangement is determined in  
20 consideration of various factors such as the apparatus cost and size, the target printing speed, and the size of the target printing medium.

As described above, a conventional printer adopts a buffer memory for each printhead, and a different  
25 printhead arrangement requires a different buffer memory arrangement. In the embodiment, the buffer memory is assigned to each nozzle to enable using

buffer memories with the same arrangement regardless of the printhead arrangement.

The buffer memory is accessed by the buffer controller 2 shown in Fig. 2.

5           This will be explained with reference to Figs. 13 and 14. Figs. 13 and 14 show a state in which the printing data memory 6 stores the same data. The printing data memory 6 stores printing data C0, C1, and C2 for respective colors. This storage state  
10 corresponds to the printing direction of the printing medium. An arrow A indicates the main scanning direction, and an arrow B indicates the nozzle array direction (convey direction).

Of stored data, data to be read out are data 131,  
15 132, and 133 in Fig. 13 or data 141, 142, and 143 in Fig. 14. Area sizes for these data correspond to 16 bits in the direction indicated by the arrow A and the number of nozzles in the direction indicated by the arrow B.

20           Fig. 13 is an explanatory view when nozzle arrays are serially arranged, as shown in Fig. 3. In this case, as shown in Fig. 13, the data 131, 132, and 133 are read out from their areas, and stored in one of the buffer memories 7-1 and 7-2. In the nozzle array  
25 direction, data are read out from addresses in correspondence with the distance between nozzle arrays. These read out addresses have the same offset amount

with respect to the main scanning direction.

Fig. 14 is an explanatory view when nozzle arrays are parallel-arranged, as shown in Fig. 4. In this case, as shown in Fig. 14, the data 141, 142, and 143 are read out from their areas, and stored in one of the buffer memories 7-1 and 7-2. In the main scanning direction, data are read out from addresses in correspondence with the distance. These read out addresses have the same offset amount with respect to the nozzle array direction.

In this manner, printing data are read out from the printing data memory 6 in correspondence with the nozzle array arrangement, and stored at addresses in the buffer memories 7-1 and 7-2.

In the embodiment, like the arrangement example of the buffer memory 7 shown in Fig. 1, buffer memories corresponding to all nozzles as buffer memories for storing printing data are combined into one buffer memory 7. Data write/read for each nozzle is controlled in accordance with information (the number of colors for printheads, the number of nozzles of each printhead, the divisional driving number, the distance between nozzle arrays, and the like) stored in the register of the head parameter unit 4, regardless of whether printheads are serially arranged (Fig. 3) or parallel-arranged (Fig. 4). This arrangement can generate data for a nozzle by the same logical circuit

regardless of the head arrangement shown in Fig. 3 or 4.

In the block diagram of Fig. 2, the buffer memory 7 is divided into two buffer memories 7-1 and 7-2 in order to execute data transfer to the printhead at higher speed by transferring data to the buffer controller 2 from one buffer memory and receiving data from the printing data memory 6 by the other one when printing data saved in the buffer memory 7 is to be transferred to the printing data converter 3 via the buffer controller 2. As will be described later, the buffer memories 7-1 and 7-2 alternately transfer and receive data. Data of 16 columns are alternately transferred to the printing data converter, and all column data for one main scanning are transferred.

In transferring data from the buffer memories 7-1 and 7-2 (reading out data from the buffer memories), raster data is converted into column data. Conversion processing will be described later.

Data transfer operation to the printhead according to the embodiment will be explained.

The head parameter unit 4 stores information on the printhead arrangement. Fig. 9 shows an example of information stored in the register incorporated in the head parameter unit 4. More specifically, the register stores the number (c\_num) of nozzle arrays, the number (n\_num) of nozzles which form each nozzle array, information (n1\_diff) representing a position where

printing data of the next nozzle is stored in the  
 printing data memory 6, pieces of information (c0\_diff,  
 c1\_diff, and c2\_diff) representing addresses at which  
 printing data of the next nozzle array are stored in  
 5 the printing data memory 6, and information  
 (bm\_strt\_adr) representing a position where the first  
 data of printing data is stored. Note that c\_num may  
 represent the number of colors for printheads.

Data management in the buffer 7 using the number  
 10 c\_num of nozzle arrays and the number n\_num of nozzles  
 of each nozzle array will be explained using an example  
 of the buffer arrangement in Fig. 1. The number of  
 colors for printheads adopted in the example of Fig. 1  
 is three, i.e., C0, C1, and C2, and one nozzle array  
 15 corresponds to one color. Hence, c\_num is three.  
 Assume that the numbers n\_num of nozzles of the three  
 nozzle arrays C0, C1, and C2 are n, m, and l, and the  
 number of printing data storage elements (arrays) of  
 the buffer memory 7 is N ( $n + m + l < N$ ). The address  
 20 of the buffer memory 7 designates an array, and takes a  
 value of 0 to N-1. The numbers n, m, and l of nozzles  
 may be equal or different. Also, the number of colors  
 is not limited to three.

When data are stored in the buffer memory 7 in  
 25 the order of C0, C1, and C2, printing data  
 corresponding to n nozzles 0 to n-1 of the nozzle array  
 C0 are stored at addresses 0 to n-1 in the buffer

memory 7. Printing data corresponding to m nozzles 0 to m-1 of the nozzle array C1 are stored at addresses n to n+m-1 in the buffer memory 7. Printing data corresponding to l nozzles 0 to l-1 of the nozzle array C2 are stored at addresses n+m to n+m+l-1 in the buffer memory 7. Addresses n+m+l to N-1 in the buffer memory 7 are not used in this example.

Read processing from the buffer memory 7 will be described with reference to Fig. 10.

10        Read from the buffer 7-1 will be explained. Read from the buffer 7-2 is the same as that from the buffer 7-1, and a description thereof will be omitted.

      Data is read out from the buffer memory by using the column counter 122 and column division counter 124 shown in Fig. 12. Either counter has an initial value of 0.

      Data of 16 bits is stored at one address. Data in the first column is read out. Since the number of simultaneously driven bits is three, data are read out bit by bit from addresses 0, 8, and 16. In this case, address 0 is accessed to read out bit data 01. Address 8 is then accessed to read out bit data 81, and address 16 is accessed to read out bit data 161. In this manner, data read out bit by bit form 16-bit data to convert raster data into column data. Upon the completion of read from addresses 0, 8, and 16, the column division counter 124 is counted up to 1.

Data read bit by bit are temporarily held in the data pack register 123 in Fig. 12. After data of three bits to be simultaneously driven are stored, the data are transferred to the printing data converter 3.

5        Data are read out bit by bit from addresses 1, 9, and 17, and stored in the data pack register 123. The data stored in the data pack register 123 are transferred to the printing data converter 3. At this time, the column division counter 124 is counted up to  
10    2.

      Data read is sequentially executed, and after data at addresses 7, 15, and 23 are transferred to the printing data converter 3, the column division counter 124 is counted up to 8. Since the value of the column  
15    division counter 124 is 8, the buffer controller 2 determines that data of the first column have been transferred. The column counter 122 is counted up to set 1, and the value of the column division counter 124 is cleared to 0.

20        As for data in the second and subsequent columns, the read address is changed to similarly access the buffer. For example, in read from the second column, addresses 0, 8, and 16 are sequentially accessed to read out bit data 02, 82, and 162. The readout data  
25    are temporarily held in the data pack register 123. Similar to the first column, data are read out up to data at addresses 7, 15, and 23. The column counter

122 is counted up to set 2, and the value of the column  
division counter 124 is cleared to 0. This operation  
is subsequently repeated up to the 16th column, data  
are read out from the buffer memory, and the column  
5 counter 122 is counted up. If the value of the column  
counter 122 reaches 16, the buffer controller 2  
determines that read from the buffer 7-1 has been  
completed. In this way, read control is done on the  
basis of the values of the column counter 122 and  
10 column division counter 124.

Read processing is performed in correspondence  
with the printhead driving method. One of printhead  
driving methods is distributed driving of driving a  
predetermined number of nozzles. For example, when  
15 nozzles are simultaneously driven every nine nozzles in  
a printhead having 24 nozzles, the first, ninth, and  
17th nozzles of the printhead are simultaneously  
driven. In this case, data corresponding to three  
nozzles described above are transferred to the  
20 printhead.

The embodiment employs distributed driving of  
driving every nine nozzles, as described above, and the  
buffer is accessed every nine addresses. In driving  
every five nozzles, the buffer is accessed every five  
25 addresses. By accessing each address, the printing  
apparatus can cope with any distributed driving value.  
The buffer controller 2 can accurately transfer



printing data to the printhead by referring to information on the distributed driving number that is stored in the head parameter unit 4.

In the embodiment, data are read out bit by bit  
5 and stored in the data pack register 123.

Alternatively, data may be read out and stored every plurality of bits in accordance with the format of data stored in the printing data memory.

The data size (data width or the number of bits)  
10 serving as the printing data storage unit of the buffer memory 7 is determined by the system configuration condition. This condition is determined in consideration of the time taken to read out the next printing data from one buffer while using the other  
15 buffer for generation of printing data when the printing controller 1 alternately switches and uses two buffer memories, as described above, or the data width (8 bits, 16 bits, 32 bits, or the like) used in the system.

20 The flow of buffer control processing in the above arrangement will be described with reference to the flow chart of Fig. 5 and the timing charts of Figs. 6A to 6I.

Write in the buffer memory 7 by the buffer  
25 controller 2 starts in accordance with an instruction from the CPU 5. Prior to the start of printing, the CPU 5 stores printing data necessary for printing in

the printing data memory 6. In write in the buffer memory 7, the buffer controller 2 reads out necessary data from the printing data memory 6. The memory controller 12 performs two operations: an operation  
5 corresponding to access from the CPU 5, and an operation of transferring printing data to the buffer controller 2 on the basis of a request from the buffer controller 2.

Signals shown in the timing charts of Figs. 6A to 6I will be explained. A position pulse (Fig. 6A) is a  
10 signal generated by the encoder of the printing mechanism driving unit 9 or the like, and a position count (Fig. 6B) is generated on the basis of this signal. A column pulse (Fig. 6D) is generated from the  
15 position pulse (Fig. 6A) by the printing timing controller 8 in correspondence with a column subjected to printing. The column pulse is divided into a plurality of pulses to generate column division pulses (Fig. 6E) used to drive the printhead. A data request  
20 pulse (Fig. 6F) to the buffer controller 2 is generated from the column division pulse. Figs. 6G, 6H, and 6I show the signals in Figs. 6D, 6E, and 6F which are enlarged along the time axis.

The buffer controller 2 starts storage processing  
25 for the buffer 7 in response to a start instruction from the CPU 5. A printing data memory address `rd_adr` is set in an initial value `bm_strt_adr`. Printing data

read out from rd\_adr in the printing data memory 6 is stored at address 0 in the buffer memory 7-1 on the basis of the buffer arrangement of Fig. 1. Printing data read out from bm\_strt\_adr+nl\_diff is stored at address 1 in the buffer memory 7-1, and printing data from bm\_strt\_adr+nl\_diffx(n-1) is stored at address n-1. Letting k be the address of the buffer memory, rd\_adr and the buffer memory address have a relationship:

10           c0: rd\_adr = bm\_strt\_adr + nl\_diff x (k-1)  
              c1: rd\_adr = bm\_strt\_adr + nl\_diff x (k-2) +  
              c0\_diff  
              c2: rd\_adr = bm\_strt\_adr + nl\_diff x (k-3) +  
              c0\_diff + c1\_diff

15           Based on this relationship, printing data are sequentially stored in the buffer memory 7-1. "rd\_adr" is not always calculated by the above relation, but address calculation processing by hardware is done for the previous result to acquire address information of the printing data memory 6. Read processing from the printing data memory and storage processing in either of the buffers 7-1 and 7-2 are executed. These series of processes (first processing: address calculation processing, second processing: read processing from the printing data memory on the basis of the address calculation result, and third processing: storage processing of readout data in the buffer) are repeated

to store data of each address of the printing data memory 6 in the buffer memory 7 (step S501).

In this case, the processing is executed while referring to the values of the color counter 125 and  
5 nozzle counter 126 in Fig. 12. If a predetermined value is obtained on the basis of information in the head parameter unit 4, the flow advances to the next processing.

For example, data C0 are read out from the  
10 printing data memory, and sequentially stored in the buffer memory 7-1. Every time one data is stored, the nozzle counter 126 is counted up, and whether a predetermined number of data have been stored is determined by a comparator on the basis of the value  
15 C0\_n\_num. If the comparator detects that all n data C0 have been stored, the color counter 125 is counted up to set 1. The nozzle counter 126 is then cleared to 0.

Similarly, data C1 are read out from the printing data memory, and sequentially stored in the buffer  
20 memory 7-1. If the comparator detects on the basis of the value C1\_n\_num that all m data C1 have been stored, the color counter is counted up to set 2. The nozzle counter 126 is then cleared to 0.

Similarly, after data C2 are stored, the color  
25 counter is counted up to set 3. Based on the value c\_num, data of 16 columns are determined to have been stored for all color data. Data of the next 16 columns

are stored in the buffer memory 7-2.

After the end of storing data in the buffer memory 7-1, subsequent printing data are read out from the printing data memory 6 and stored in the buffer  
5 memory 7-2 by using the sum of the previous address rd\_adr and cl\_diff as address 0 of the buffer memory 7-2. This processing is repeated to store printing data (step S502).

If the start of printing operation is detected  
10 (step S504) after the buffer memory changes to a transfer standby state (step S503), a request for data transfer to the printing data converter 3 that is issued from the printing timing controller 8 to the buffer controller 2 is detected from reception of a  
15 data request pulse shown in Figs. 6F and 6I that is generated in accordance with position information (e.g., the position pulse shown in Fig. 6A and the position count in Fig. 6B) transferred from the printing mechanism driving unit 9 to the printing  
20 timing controller 8 (step S505). Data transfer from the buffer memory 7-1 by the buffer controller 2 is then executed.

In Figs. 6A to 6I, four column pulses are output at a position count P. For example, the column pulse  
25 shown in Fig. 6D is output four times, and all data of 16 columns are read out from the buffer 7-1. When the next four column pulses are to be output, data are read

out from the buffer 7-2.

Data output at the column division pulse in Fig. 6E is data held in the data pack register 123 described with reference to in Fig. 10.

5       The number of column division pulses corresponding to one column pulse is 16, but 8 in the case of Fig. 10.

      The buffer controller 2 supplies a signal representing that data transmitted from the buffer  
10 controller 2 to the printing data converter 3 is valid. The printing data converter 3 supplies printing data to the printhead.

      If data transfer from the buffer memory 7-1 to the buffer controller 2 is determined (step S506), data  
15 is transferred for each storage unit of the buffer memory in correspondence with the data request pulse in Figs. 6F and 6I (step S507). Every time the data request pulse is received, data transfer of the storage unit is repeated. After data request pulses  
20 corresponding to the number of data stored in the buffer memory 7-1 are output, all data in the buffer memory 7-1 are determined to have been used (step S508). At this time, the transfer standby state shifts from the buffer memory 7-1 to the buffer memory 7-2  
25 (step S509), and transfer of printing data stored in the printing data memory to the buffer memory 7-1 starts (step S510).

Whether printing has ended is determined from the signals in Figs. 6A to 6C (step S515). If NO in step S515, the flow returns to step S505 in order to transfer data from the buffer 7-2 to the printing data converter 3 in response to a data request for the next  
5 four column pulses.

At this time, the flow advances from step S506 to step S511 because of data transfer from the buffer memory 7-2. Similar to the above processing, every  
10 time the data request pulse is received, data transfer of each array is repeated. After data request pulses corresponding to the number of data stored in the buffer memory 7-2 are output, all data in the buffer memory 7-2 are determined to have been used (step  
15 S512). At this time, the transfer standby state shifts from the buffer memory 7-2 to the buffer memory 7-1 (step S513), and transfer of printing data stored in the printing data memory to the buffer memory 7-2 starts (step S514).

20 If the end of printing is determined in step S515, buffer control processing ends. Note that storage processing in the buffers 7-1 and 7-2 is not limited to processes in steps S501 and S502. Alternatively, data may be stored in the buffer memory  
25 7-1 before the start of printing and stored in the buffer memory 7-2 after the start of printing as far as data storage catches up with printing operation.

### <Concrete Example of VHDL>

The arrangement according to the embodiment will be described for a description example using a hardware description language. Figs. 8A to 8K show a  
5 description example when VHDL is adopted as a hardware description language in the arrangements of the buffer controller 2 and a printing data memory read controller 11 in the block diagram of Fig. 2. This description example is based on the flow chart of Fig. 5, and one  
10 processing covers a plurality of processes in the flow chart of Fig. 5. The contents of the description will be explained.

In Fig. 8A, a part which starts from "entry" and ends at "end" declares input/output of the entire  
15 block. Contents within GENERIC() of this part form a description which declares variables allowing change of the data size used in this block to a size optimal for use in another system. In this example, these contents describe an application to a system in which the  
20 maximum value of an array in the lateral direction, i.e., the maximum number of printing positions by one scanning is 8,192 (0 to 8,191: X\_MSB = 13), the width of data from the buffer controller 2 to the printing data converter 3 has 6 bits (B\_NUM = 5), the address  
25 used to access the external printing data memory 6 has 22 bits, and the data width has 32 bits (A\_LSB = 2).

Contents within port() define input and output



signals to and from the block. This example is applied to a system which performs printing four types of pieces of information. A signal uniquely used for each information is identified by determining which of C0\_,  
5 C1\_, C2\_, and C3\_ is added to the head of a signal name. Further, this example is applied to a system which divides the nozzles of the printhead into 16 blocks and drives them in time division.

Parts in Figs. 8B to 8K which start from  
10 ARCHITECTURE RTL OF and end at END RTL; are logical descriptions for executing the operation of the embodiment. The part in Fig. 8B defines constants (CONSTANT) and signals (SIGNAL) used in the logical description. The parts in Figs. 8C to 8K describe  
15 actual logics.

Contents in Figs. 8C to 8K will be explained in more detail.

The block in this example starts initialization by setting an "init" input to "1", and executes  
20 activation after initialization when the "init" input changes to "0". After the start of activation, an initialization pulse and a read activation pulse for a request from the printing timing controller 8 are generated in accordance with the description of a part  
25 801 (part of step S501).

Parts after the part 801 in Fig. 8C to Fig. 8F are descriptions for controlling data read from the

buffer memory in accordance with the printhead arrangement (S504, S505, S507, part of S511, and S515).

A part shown in Fig. 8G is a description for detecting the use states of buffers in order to  
5 alternately use two memory buffers (steps S506, S508, S509, S512, and S513).

A part shown in Fig. 8H is a description for converting data read out from the buffer memory by the printing data converter 3 in accordance with the  
10 printhead arrangement and generating data with a requested arrangement (step S507 and part of step S511).

A part shown in Fig. 8I is a description for writing data in the buffer memory in accordance with  
15 the state detected in accordance with the description shown in Fig. 8G in order to alternately use the two memory buffers (steps S510 and S514).

A part shown in Fig. 8J is a description for, when a write request to the memory buffer is generated  
20 by the part shown in Fig. 8I, requesting data of the external printing data memory 6, detecting a response to the request, and notifying the block in Fig. 8I that valid data has been supplied from the printing data memory 6 (part of step S501, and processing associated  
25 with the data save portion in S514 and S510).

A part shown in Fig. 8K is a description for, when data is requested of the printing data memory 6 in

accordance with the part shown in Fig. 8J, calculating a location (address) where necessary data exists in the printing data memory 6 in accordance with the progress of printing, and generating the calculated address at a requested timing (this description executes part of step S501, and steps S502, S503, S514, and S510).

<Other Embodiment>

In the above description, the present invention is applied to an ink-jet printer. However, the present invention can also be applied to a printing apparatus which employs a method other than the ink-jet method as far as the present invention is of a serial type.

The present invention can be applied to a system comprising a plurality of devices (e.g., host computer, interface, reader, printer) or to an apparatus comprising a single device (e.g., copying machine, facsimile machine).

Furthermore, the invention can be implemented by supplying a software program, which implements the functions of the foregoing embodiments, directly or indirectly to a system or apparatus, reading the supplied program code with a computer of the system or apparatus, and then executing the program code. In this case, so long as the system or apparatus has the functions of the program, the mode of implementation need not rely upon a program.

Accordingly, since the functions of the present

invention are implemented by computer, the program code installed in the computer also implements the present invention. In other words, the claims of the present invention also cover a computer program for the purpose  
5 of implementing the functions of the present invention.

In this case, so long as the system or apparatus has the functions of the program, the program may be executed in any form, such as an object code, a program executed by an interpreter, or scrip data supplied to  
10 an operating system.

Example of storage media that can be used for supplying the program are a floppy disk, a hard disk, an optical disk, a magneto-optical disk, a CD-ROM, a CD-R, a CD-RW, a magnetic tape, a non-volatile type  
15 memory card, a ROM, and a DVD (DVD-ROM and a DVD-R).

As for the method of supplying the program, a client computer can be connected to a website on the Internet using a browser of the client computer, and the computer program of the present invention or an  
20 automatically-installable compressed file of the program can be downloaded to a recording medium such as a hard disk. Further, the program of the present invention can be supplied by dividing the program code constituting the program into a plurality of files and  
25 downloading the files from different websites. In other words, a WWW (World Wide Web) server that downloads, to multiple users, the program files that

implement the functions of the present invention by computer is also covered by the claims of the present invention.

It is also possible to encrypt and store the  
5 program of the present invention on a storage medium such as a CD-ROM, distribute the storage medium to users, allow users who meet certain requirements to download decryption key information from a website via the Internet, and allow these users to decrypt the  
10 encrypted program by using the key information, whereby the program is installed in the user computer.

Besides the cases where the aforementioned functions according to the embodiments are implemented by executing the read program by computer, an operating  
15 system or the like running on the computer may perform all or a part of the actual processing so that the functions of the foregoing embodiments can be implemented by this processing.

Furthermore, after the program read from the  
20 storage medium is written to a function expansion board inserted into the computer or to a memory provided in a function expansion unit connected to the computer, a CPU or the like mounted on the function expansion board or function expansion unit performs all or a part of  
25 the actual processing so that the functions of the foregoing embodiments can be implemented by this processing.

If the present invention is realized as a storage medium, program codes corresponding to the above mentioned flowcharts and/or descriptions of the hardware description language (Fig. 5 and/or Figs. 8A  
5 to 8K) are to be stored in the storage medium.

As many apparently widely different embodiments of the present invention can be made without departing from the spirit and scope thereof, it is to be understood that the invention is not limited to the  
10 specific embodiments thereof except as defined in the appended claims.